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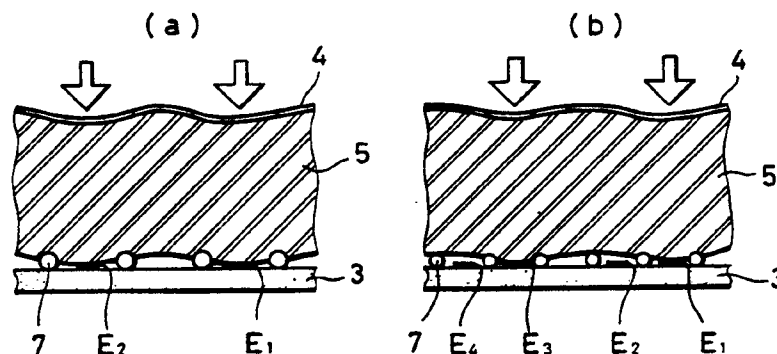
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(54) Pressure-sensing electric conductor and its manufacturing method

(57) A pressure-sensing electric conductor comprises an elastic electrically conductive layer 5 made of silicone rubber, on which a flexible insulating resin layer 7 having a network of holes is overlaid. The pressure-sensing electric conductor is produced by coating a flexible sheet of resin insulating material having a number of holes with a silicone adhesive containing toluene and silicone ink, and adhering the sheet to a vulcanised electrically conductive silicone rubber sheet by pressure bonding them together.

FIG. 1



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FIG. 1

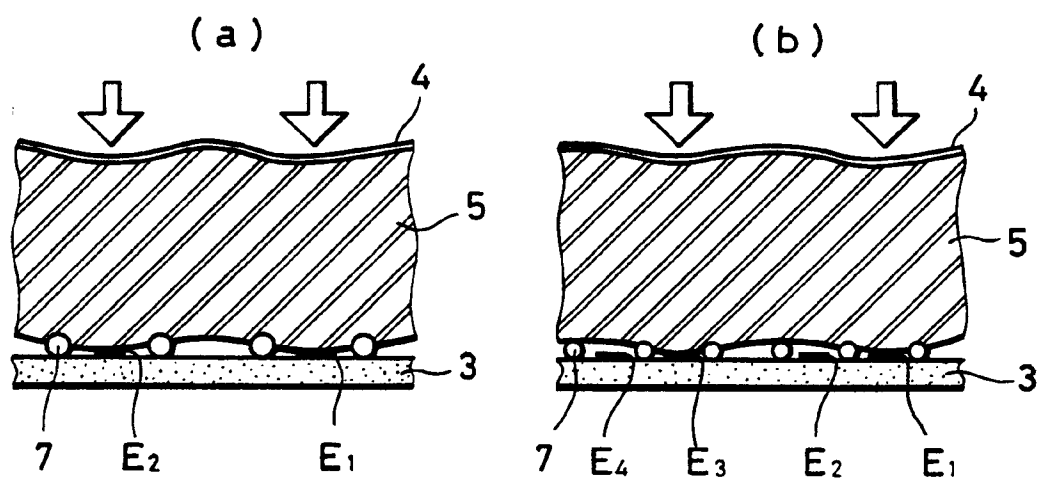
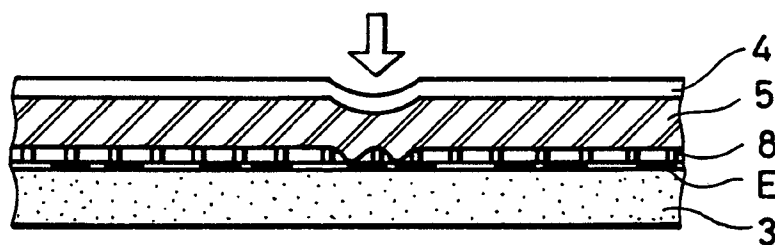


FIG. 2



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FIG. 3

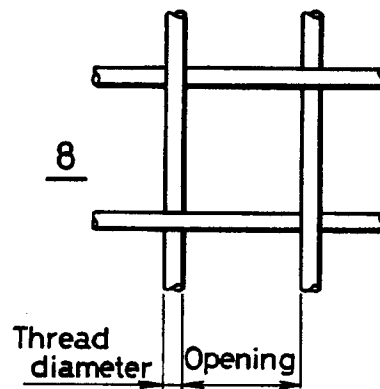


FIG. 4

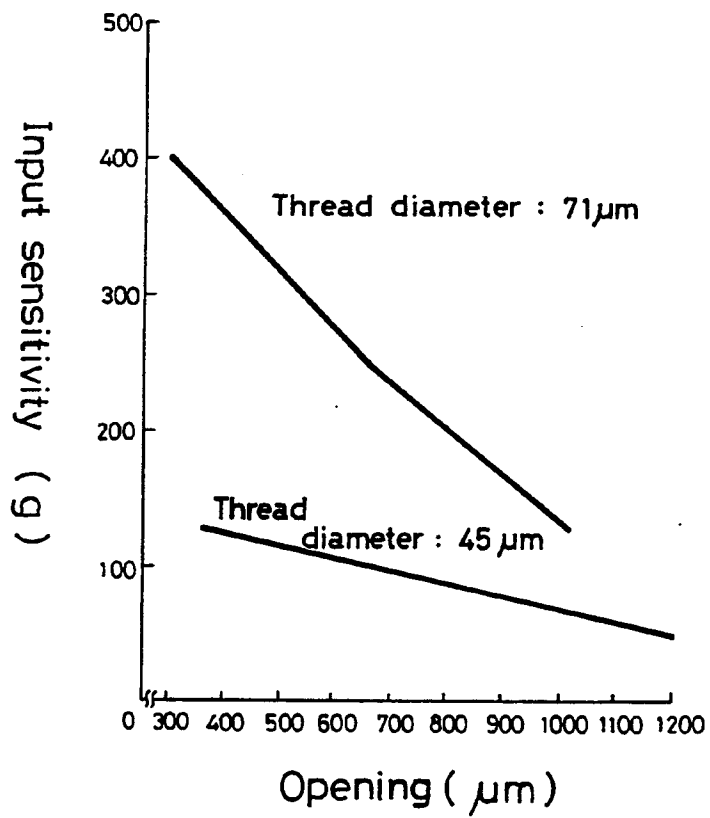


FIG. 5

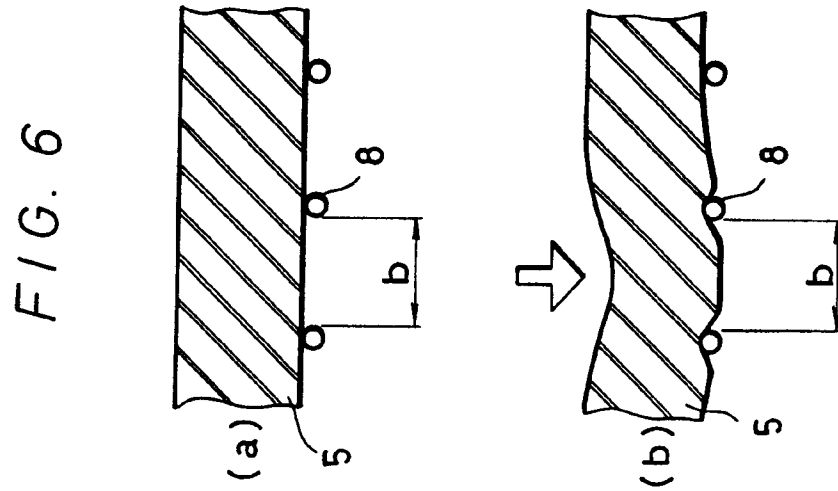
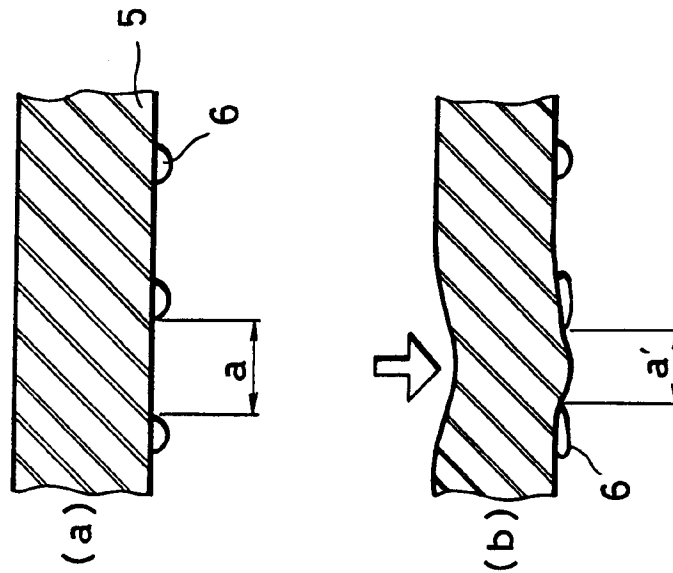


FIG. 7

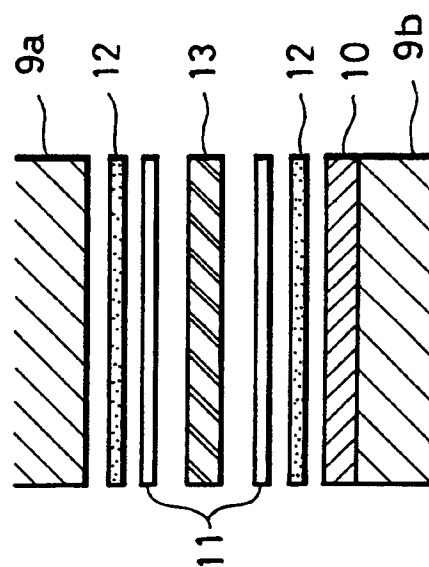
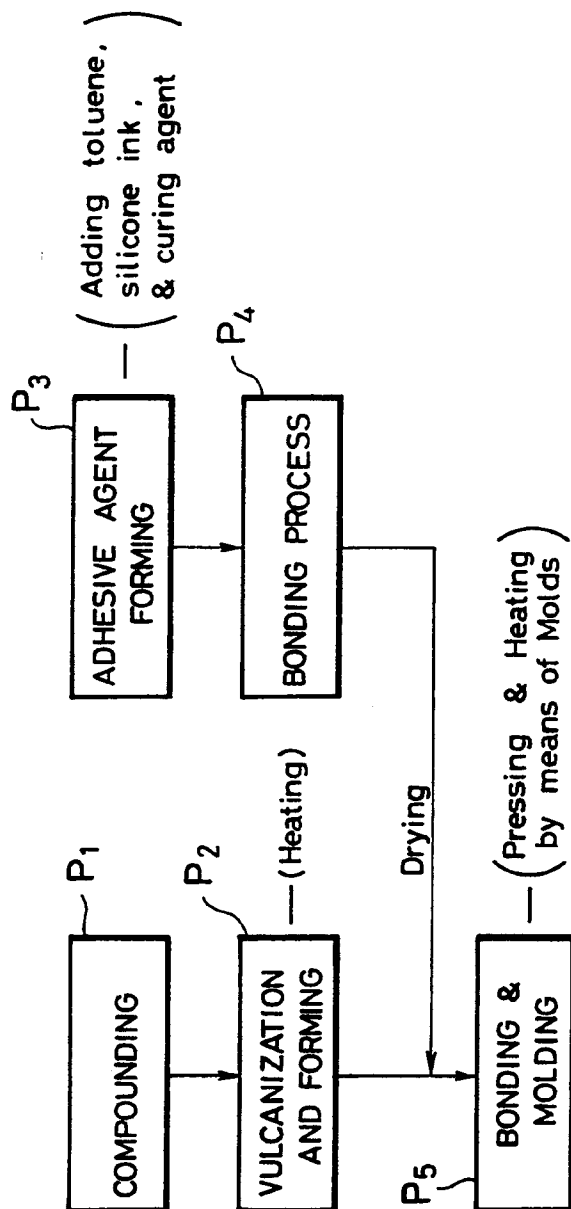


FIG. 8

FIG. 9

PRIOR ART

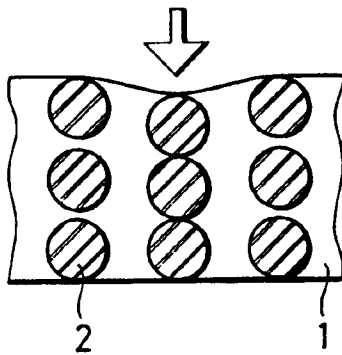


FIG. 10

PRIOR ART

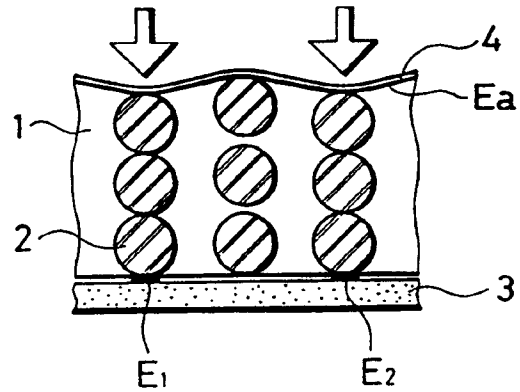


FIG. 11

PRIOR ART

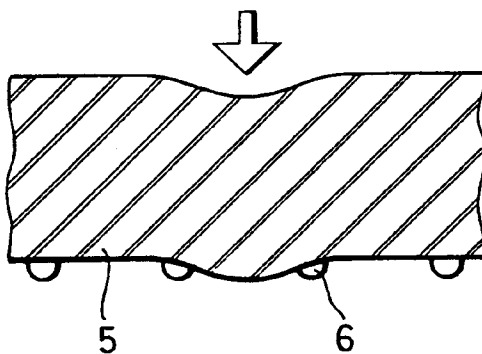
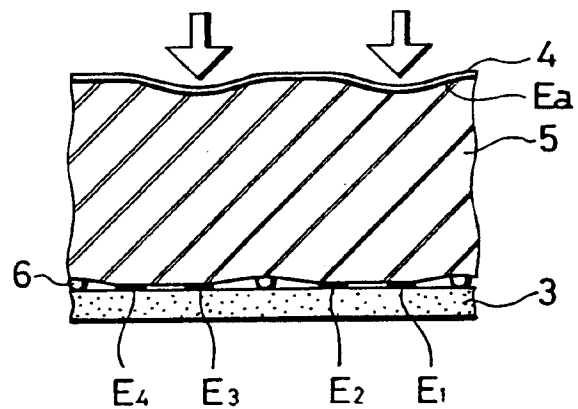


FIG. 12

PRIOR ART



PRESSURE-SENSING ELECTRIC CONDUCTOR  
AND  
ITS MANUFACTURING METHOD

5 This invention relates to a pressure-sensing  
electric conductor used in a graphic input device  
and/or switching device of a computer system, and  
to the manufacturing method thereof.

10 A pressure-sensing electric conductor which becomes  
conductive when impressed by exterior force is widely  
used in prior art. Figure 9 is a sectional view of an  
embodiment of the pressure-sensing electric conductor  
disclosed in Japanese Patent Laid Open Publication No.  
897/1978. Said pressure-sensing electric conductor is  
15 obtained by filling the rubber 1, an elastic body, with  
metal particles 2, and then making admixture thereof.  
When pressure is applied on said conductor from the  
direction indicated by the arrow in the drawing, the  
metal particles located in the portion where pressure is  
applied contact each other to form a link of conductive  
20 substance from one end to the other. Figure 10 is an  
embodiment of said pressure-sensing electric conductor  
applied to a tablet or switching device. The rubber 1  
filled with metal particles 2 is interposed between a  
substrate 3 and a flexible protective sheet 4, and the  
25 electrodes  $E_1$  and  $E_2$  in stripes are formed on the inner  
side of the substrate 3. When pressure is applied in the  
direction shown by an arrow in the drawing the impressed

spot becomes conductive.

Figure 11 is an embodiment of the pressure-sensing electric conductor of prior art, disclosed in Japanese Utility Model laid open under No. 41588/1981. Said pressure-sensing electric conductor is obtained by means of printing a pattern using the insulating ink 6 on an elastic electric conductive sheet 5. Figure 12 shows said pressure-sensing electric conductor being applied to a tablet or a switch. When pressure is not applied on the conductor, the insulating ink 6 separates the electric conductive sheet 5 from the electrodes  $E_1 \sim E_4$ , and when pressure is impressed over the protective sheet 4, the electric conductive sheet 5 is deformed, and its portion where pressure is applied touches the electrode to become electric conductive.

The pressure-sensing electric conductor is generally provided by filling the elastic rubber 1 with metal particles 2 and forming an admixture thereof, or by printing a pattern of the insulating layer using the insulating ink 6 over the flexible electric conductive sheet 5. These pressure-sensing electric conductors may not provide satisfactory characteristics in the sensitivity, durability, and resolution because of the use of metal particles 2 or insulating ink 6.

As an alternative, an insulating layer made of resin and having a number of holes to be laminated over a sheet form of electric conductor is suggested. Said pressure-



sensing electric conductor having an insulating layer of resin, such as polyester mesh and the like, is not liable to deterioration over elapsed time, and has improved sensitivity characteristics and durability.

5           The pressure-sensing electric conductor using metal particles, as shown in Figures 9 and 10, generates varying resistance when conducting electricity because of the oxidizing of metal particles 2, giving cause to chattering at a spot where the conductor is applied with  
10           pressure because of a number of metal particles contacting each other, and thus causes the sensitivity to deteriorate over the elapsed time, and also results in costlier operation of a device it is applied with.

          The pressure-sensing electric conductor, as shown in  
15           Figures 11 and 12, where a pattern of the insulating layer is printed using the insulating ink 6 over the flexible electric conductive sheet 5, the distances and thickness the insulating patterns formed by using said insulating ink 6 have certain limitations that preclude  
20           optional determination of the input sensitivity, and at the same time provide the durability against the repeated impressions limited to a certain extent.

          These pressure-sensing electric conductors may not provide satisfactory characteristics in the sensitivity,  
25           durability, and resolution because of the use of metal particles 2 or insulating ink 6. The pressure-sensing electric conductors of prior art having the insulating

layer of resin are produced by coating adhesive agent on the insulating substance of resin material, simply adhering it over a sheet form of electric conducting substance, and by pressing them together, and thus fail  
5 to attain either sufficient adhesive strength or satisfactory sensitivity characteristics.

An object of this invention is therefore to provide a pressure-sensing electric conductor having improved sensitivity characteristics, durability, and capability  
10 of determining the input sensitivity at the desired level, and is simple in structure and therefore less expensive to produce.

The pressure-sensing electric conductor of this invention is provided by having a flexible insulating layer made of resin and having a number of holes in a  
15 pattern of net overlaid on an elastic electric conductive layer made of silicone rubber.

Another object of this invention is to provide a processing method whereby a pressure-sensing electric  
20 conductor may be obtained with sufficient adhesive strength between the electric conductive body and the insulating body to obtain the satisfactory sensitivity characteristics.

The pressure-sensing electric conductor of this  
25 invention is produced by coating a silicone adhesive agent added with toluene and silicone ink on a flexible

sheet form made of silicone insulating substance perforated with a number of holes, overlay said resin insulating sheet on the elastic vulcanized sheet form of electric conductive substance, and then by pressing both  
5 the resin insulating and electric conductive sheets together.

Figure 1 (a) and (b) are cross sections indicating the basic structure of the pressure-sensing electric conductor of this invention.

10 Figure 2 is a cross section of an embodiment of this invention.

Figure 3 is a plan view showing the form of the polyester mesh of the Figure 1.

15 Figure 4 is a graph of characteristic plottings indicating the relationship between the openings of the polyester mesh and the degree of input sensitivity.

Figure 5 (a) and (b) are the cross sections of pressure-sensing electric conductor of prior art at the time when pressure is applied.

20 Figure 6 (a) and (b) are the cross sections of pressure-sensing electric conductor of present invention at the time when pressure is applied.

Figure 7 is a schmatic illustration of the manufacturing process whereby the pressure-sensing electric  
25 conductor of this invention is produced.

Figure 8 is the cross section of the pressure-

sensing electric conductor of Figure 7 for illustrating the steps of bonding process.

Figure 9 is the cross section of a pressure-sensing electric conductor of prior art.

Figure 10 is the corss section of an embodiment of the pressure-sensing electric conductor of Figure 9 being applied to a tablet or switch.

Figure 11 is the cross section of another type of pressure-sensing electric conductor.

Figure 12 is the corss section of an embodiment of the pressure-sensing electric conductor of Figure 11 being applied to a tablet or switch.

Figure 1 illustrates the basic structure of the pressure-sensing electric conductor of this invention, made for use on a tablet or switch used for entering coordinate inputs into a computer system. In the drawing, the electric conductive layer comprises an insulating substrate 3, an outer protective sheet 4, and an elastic electric conductive sheet 5. A flexible insulating layer of resin having a number of holes 7 adjoins said electric conductive sheet 5, and the  $E_1 \sim E_4$  are the electrodes disposed to form stripes of electrode layer on the substrate 3, adjoining an insulating layer 7 made of resin.

Said electric conductive sheet 5 is made of silicone rubber, and the resin insulating layer 7 is formed in a

net pattern.

The pressure-sensing electric conductor comprising said electric conductive sheet 5 and the resin insulating layer 7 deforms at the spot where exterior pressure is applied, contacts the electrode to form electric conductive state. Since metal particles of prior art are not used, it is neither liable to considerable deterioration over elapsed time nor chattering, and has enhanced sensitivity characteristics. Furthermore, the conductor is less expensive and simple in construction, and electrodes E<sub>1</sub> and E<sub>2</sub> may be made conductive with each other as shown in Figure 1 (a) since it becomes possible to form a conductive state in other directions than the direction to which the pressure is applied. Since the flexible resin insulating layer 7 of stronger durability against applied pressure is used instead of the insulating ink, and because the insulating pattern thereof is selectable at an optional level, the input sensitivity may be set as desired. Consequently, if pressure is applied at the electrodes E<sub>1</sub> and E<sub>3</sub>, as shown in Fig. 1 (b), only those E<sub>1</sub> and E<sub>3</sub> become conductive, while the other electrodes remain insulated.

Fig. 2 is a sectional view of an embodiment of the present invention, wherein the numeral 8 denotes a polyester mesh (resin insulating layer), and E denotes the electrode.

The polyester mesh 8 formed as insulating layer is

structured with crossing threads and open spaces formed  
inbetween, as shown in Fig. 3, providing elasticity  
against pressure applied repetitively. Figure 4 is a  
graph of characteristic plottings indicating the  
5 relationship between the openings of the polyester mesh  
(in  $\mu$  m) and the degree of input sensitivity (g). The  
input sensitivity may be increased by adopting smaller  
thread diameter and wider opening, as illustrated in the  
graph. Since polyester used as raw material of the  
10 thread is of nature capable of providing a thread of  
comparatively smaller diameter, a tablet for coordinate  
input which uses polyester mesh 8 as insulating layer may  
have a stronger power of resolution. The tablet for  
coordinate input of the embodiment will, when pressure is  
15 applied to the electric conductive sheet 5, have the  
pressured portion of said electric conductive sheet 5  
squeezed into the space between the threads of the  
polyester mesh 8 to contact the electrode E. Once the  
pressure applied on the electric conductive sheet 5 is  
20 released, said sheet 5 will return to its original posi-  
tion due to its elasticity.

The pressure-sensing electric conductor of prior art  
using the insulating ink as the insulating layer, and a  
pressure-sensing electric conductor of this invention  
25 using resin material for the same purpose are compared of  
their respective state when pressure is applied: The  
conductor of prior art will have distortion in the insu-

latinsulating ink 6 from the exerted pressure and thus shrinking the distance "a" between said solidified ink and adjoining solidified ink to "a'" ( $a > a'$ ) to result in reduced power of resolution, while the embodiment of this invention will on the contrary, as shown in Fig. 6, have the opening length "b" of the polyester mesh 8 unchanged even when pressure is applied, and will not result in the decreased power of resolution.

While the embodiment of this invention quotes a case wherein the shape of the cross section is circular, it may be angular. A thread having a square cross section is capable of making the pitch narrower. Should a nylon mesh be used instead of a polyester mesh 8, a similar functional result may be obtained.

Figure 7 is a schematic illustration of the manufacturing process whereby the pressure-sensing electric conductor of this invention is produced.

This pressure-sensing electric conductor is produced by laminating a resin insulating layer having a number of holes on the previously mentioned sheet electric conductive substance.

At the process P1, two portions of the LTV (low temperature vulcanization) type electric conductive silicone rubber (a product of Toray Silicone Company Ltd. which is called DY-118A/B by trade name) respectively containing the medium or accelerator agent are mixed, heated and vulcanized at the next process P2 into a sheet form.

At the process P3, on the other hand, the adhesive agent for coating the resin insulating sheet is prepared. Said adhesive agent is a compound of silicon adhesive agent, toluene, and silicone ink mixed together. In this particular embodiment, 7 grams of the silicone adhesive (a product of Toray Silicone Company Ltd. which is called SE1700 by trade name); 100 grams of toluene; 0.7 gram of curing agent; and 0.1 gram of silicone ink (a product of Toray Silicone Company Ltd. which is called PRK-3 by trade name) are compounded.

At the process P4, said silicone adhesive agent with toluene admixed is coated on the flexible sheet of resin insulating substance having a number of poles, ensured that the coat is securely adhered, and dried. At the process P5, said resin insulating substance and electric conductive substance are placed together and pressured from both sides for bonding by means of a metal mold as shown in Fig. 8. Specifically, the processes that take place in between the upper mold 9a and lower mold 9b are as follows:

(1) An insulating silicone sheet 10 of about 5mm in thickness (a product of Shinetsu Chemical Industry Company Ltd. which is called KE951u by trade name) is placed on the lower mold 9b.

(2) Polyester film sheets 12 of about 125 $\mu$  in thickness (a product of Toray Company Ltd. which is called Lumilar by trade name) are interposed between the



resin insulating substance sheets 11 and the upper mold 9a, and lower mold 9b, respectively.

(3) The electric conductive sheet 13 is positioned inbetween said resin insulating substance sheets.

5       (4) The molds are closed to pressurize all above mentioned layers together for bonding into the pressure-sensing electric conductor previously mentioned.

A sufficient adhesive strength may be obtained through the use of said silicone adhesive agent compounded with toluene and silicone ink. Should an  
10       ordinary adhesive agent be used, the linear strength of only about 100g/20mm may be obtained along the resin insulating substance 11, while the silicone adhesive agent of this embodiment has proved to possess the adhesive  
15       strength of 150 ~ 200g/20mm along the same direction. Since the polyester films 12 and insulating silicone sheet 10 interpose between the upper and lower molds and the resin insulating sheet 11 and electric conductive sheet 13, respectively, the pressure exerted by the molds  
20       will not result in said insulating sheet 11 biting into the electric conductive sheet 13 excessively, and thus an insulating layer of uniform thickness may be obtained. The use of the resin insulating sheet 11 eliminates the deterioration in the insulating material over elapsed  
25       time, and thus improves the sensitivity characteristics, durability, and other abilities.

The compounding ratio of the adhesive agent is not

limited to that mentioned above, and the range of mixture proportions listed in the Table 1 below may provide satisfactory adhesive strength:

TABLE 1

5	Toluene	100	grams
	Silicone adhesive agent	3~	30 grams
	Curing agent	0.3~	3 grams
	Silicone ink	0.05~	1 gram

CLAIMS

1. A pressure-sensing electric conductor comprising an elastic electric conductive layer made of silicone rubber, having a flexible resin insulating layer with a number of holes in net form overlaid thereon.  
5
2. A pressure-sensing electric conductor as claimed in claim 1 of which cross sectional form of the resin insulating layer is formed in a square.
3. A pressure-sensing electric conductor as claimed in claim 1 or claim 2 where the resin insulating layer is formed in latticework made of resin substance.  
10
4. A pressure-sensing electric conductor as claimed in claim 1 or claim 3 where the resin insulating layer is made of polyester mesh.
5. A method of producing pressure-sensing electric conductor comprising a flexible resin insulating substance in sheet form having a number of holes being coated with a silicone adhesive agent compounded with toluene and silicone ink, and an vulcanized elastic electric conductive substance in sheet form, both of which are faced and pressed together.  
15  
20
6. A method of producing pressure-sensing electric conductor as claimed in claim 5 whereby the sheets of resin insulating substance and electric conductive substance are pressed together by means of said molds.  
25
7. A method of producing pressure-sensing electric conductor as claimed in claim 6 whereby polyester films

are interposed between the molds and the resin insulating substance and electric conductive substance, respectively, before they are pressed together inbetween the molds.

5 8. A method of producing pressure-sensing electric conductor as claimed in claim 7 whereby silicone sheets are interposed between the molds and the polyester films, respectively, before they are pressed together inbetween the molds.

10 9. A pressure-sensing electric conductor comprising a flexible electric conductive layer and a flexible insulating layer with a network of holes overlaid thereon.

10. A method of producing a pressure-sensing electric conductor comprising pressing together a sheet of flexible insulating material  
15 with a network of holes and a sheet of flexible electric conductive material.

11. A pressure-sensing electric conductor substantially as hereinbefore described with reference to the accompanying drawings.

12. A method of producing a pressure-sensing electric conductor  
20 substantially as hereinbefore described with reference to the accompanying drawings.